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135a

110b

135b

**Computing
Device
110c**

**Computing
Device
110a**

Computing Device

135c

14

**Computing
Device
110d**

Communications Network

**Computing
Device
110e**

FIG. 1

10b

135d

135e

10a

Server

Server

Server

Database 20

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Fig. 2

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Fig. 3

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Fig. 4A

Fig. 4B

Fig. 4C

Fig. 4D

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Fig. 5A

Classification Chain Input Space IS

Fig. 5B

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Fig. 6A

Fig. 6B

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600

Start with the First Song of a Plurality of Unclassified Songs

605 Is Song Already in Database? — **YES** → **610** Is Training Complete? — **NO** → **615** **Next Song of Plurality of Unclassified Songs**

605 NO ↓

610 YES ↓

620 **Calculate and Present Song Vector to Classification Chain**

625 **Quit**

630 **Calculate Response of Classification Chain**

Fig. 6C

635 Is there a High Level of Confidence for Chain Output? — **NO** → **640** **Expert Classifies Song, and Song Vector Added to Classification Chain**

635 YES ↓

645 **Next Song of Plurality of Unclassified Songs**

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Fig. 7A

745
FFT

750
Critical Band
Filtering

755
Entropy

760
Derivative

765
Average of All Frames

770
Feature
Vector

775
Principal
Component
Analysis

780
Classification
Chain

Fig. 7B

High

Sad ← → Happy

Emotion

Low

Mood

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Fig. 8A

800

```
          FFT
```

802

```
    Peak Detection
```

804

```
  Critical Band Filtering
```

806

```
    Peak Continuation
```

808

```
  Consonance Calculation
```

810

```
     Feature
     Vector
```

812

```
     Principal
     Component
     Analysis
```

814

```
    Classification
        Chain
```

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Fig. 8B

816

FrameNum = 1 : NumFrames

818

Zero-pad and Take
FFT of Audio Frame

820

Diff_FFT[ ] = Successive
Differences of FFT'd
Buffer

822

FFTIndex =
1:NumBins

824

Diff_FFT(FFTIndex) > 0? —NO

YES

826

Diff_FFT(FFTIndex+1) < 0? —NO

YES

828

Record Bin &
Energy into
Output Matrices

830

FFTIndex++
FFTIndex >= LastBin?

NO

YES

834

Select Top
Requested Number
of Peaks

836

PeakNum = 1: NumPeaksRequested

838

Nth Order Interpolate Peaks'
Positions and Heights

840

PeakNum++
PeakNum > NumPeaksRequested? —NO

YES

842

FrameNum++
FrameNum > NumFrames? —NO

YES

844

FINISHED

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846
Setup Guides Based on Peaks in First Frame

848
For FrameNum = 1: NumFrames

850
PeakMatched = [ ]
GuideMatch = 0

852
For PeakNum = 1:NumPeaks

854
MinDiff = kNyquistFreq
Matched = 0
ThisPeak = Bins(FrameNum, PeakNum)
ThisEnergy = Energies(FrameNum, PeakNum)

856
For GuideNum = 1:NumGuides

858
ThisGuide = GuideFreq(GuideNum)
ThisGuideEnergy = GuideEnergy(GuideNum)

860
If ((ThisPeak Is within 1/2 Step of ThisGuide) & (PeakEnergy is within 6dB of ThisGuideEnergy) & (ThisGuide not Just Continued))
NO
YES

862
GuideMatch = GuideNum
(Record Matched Guide #)

864
guideNum++
(guideNum>numGuides)?
NO
YES

866
GuideMatch != 0
NO
YES

868
- Record this Peak & Energy into Output Matrix
- Record Possible Missed Peak in Previous Frame if ThisGuide Just Started
- PeakMatched(PeakNum) = 1
- GuideState(GuideNum) = kContinued
- GuideEnergy(GuideNum) = ThisEnergy

NO

870
PeakNum++
PeakNum > NumPeaks?
YES

872
- Locate & Record Unused Guides and Unmatched Peaks

874
Any Unused Guides or Unmatched Peaks?
NO
YES

876
Start New Guides at the Unmatched Peaks with Largest Energy

878
FrameNum++
FrameNum > NumFrames?
NO
YES

879
FINISHED

Fig. 8C

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Fig. 8D

880 FrameNum = 1 : NumFrames

882 PeakBottom = 1 : NumPeaks

884 Denom = Peak_Locations(FrameNum, PeakBottom)

886 Denom != 0? — **NO**

YES

888 PeakTop = 1 : NumPeaks

890 Numer = Peak_Locations(FrameNum, peakTop)

892 Numer != 0? — **NO**

YES

894 Ratio = Nearest_Integer [12* log2 (Numer/Denom)]

896 Is (0<Ratio<25) — **NO**

YES

898 Increment Intervals(Ratio) Array by (Energies(FrameNum, PeakBottom))^2 and (Energies(FrameNum, PeakTop))^2

900 PeakTop++ PeakTop > NumPeaks? — **NO**

YES

902 PeakBottom++ PeakBottom > NumPeaks? — **NO**

YES

904 FrameNum++ FrameNum > NumFrames? — **NO**

YES

906 Interval = Interval / NumFrames (Take the Mean)

908 Normalize Interval Vector

910 FINISHED

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Fig. 9A

900

FFT

905

Peak Detection

910

Critical Band Filtering

915

Peak Continuation

920

Melodic Movement
Calculation

925

Feature
Vector

930

Principal
Component
Analysis

935

Classification
Chain

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940

FrameNum = 1 : NumFrames

945

PeakNum = 1:numPeaks

950

Numer = Peak_Locations(FrameNum, PeakNum)

955

If (kFreqMin <= Numer <= kFreqMax) — NO

960

PitchClass = round(24*log2(Numer/ kFreqMin) - floor(log2(Numer/kFreqMin))

965

Is (0<PitchClass<25) — NO

YES

970

Melodic(FrameNum, PitchClass) = Melodic(FrameNum, PitchClass) + (Energies(FrameNum, PeakNum))

YES

975

PeakNum++ PeakNum > NumPeaks?

NO

980

FrameNum++ FrameNum > NumFrames?

NO

985

Melodic = Diff(Melodic) (Take the 1st Difference)

990

Melodic = std(Melodic) (Take Standard Deviation)

995

FINISHED

Fig. 9B

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Audio data in 16bit 44khz mono PCM format. 1020

Fig. 10

1030

Decimate data to common sampling rate, e.g. 43 Hz.

1040

Generate a data envelope that accentuates tempo characteristics while suppressing biases and trends.

1050

Generate 130 bins of data, where each bin is the "correlation strength" for the period defined by the bin number times 1/43.

1060

Feed into classification chain. For every calculated distance that is below a defined threshold, the corresponding classified tempo along with the distance is added to a table. The distance values in the table are translated into confidence values by taking 1/(distance^4). Each tempo value is divided by 10 and the log2 is taken. The integer portion is the "harmonic component" entry. The fractional portion is the "tempo component" entry.

1070

Tempo components are translated into vector representation. The range of 0 to 1 is mapped to 0 to 2pi. The sine and cosine of the angle are taken and multiplied by the corresponding confidence value. These sine and cosine components for the entire table are accumulated separately to create an overall representative vector. The angle of this vector is mapped back to a range of 0 to 1 to give an overall confidence of the tempo classification.

1080

The harmonic component of each table entry is evaluated. If the corresponding tempo component meets one of the following criteria, the harmonic is modified. If the tempo entry is less than the overall tempo classification - 0.5, the harmonic component entry is decremented. If the tempo entry is greater than the overall tempo classification + 0.5, the harmonic component is incremented. Each harmonic component table entry "votes" for its value with a weight proportional to the corresponding confidence value. The most prominent value is used as the overall harmonic component.

1090

The overall tempo is calculated by calculating 2^(overall harmonic component + overall tempo component) multiplied by 10.